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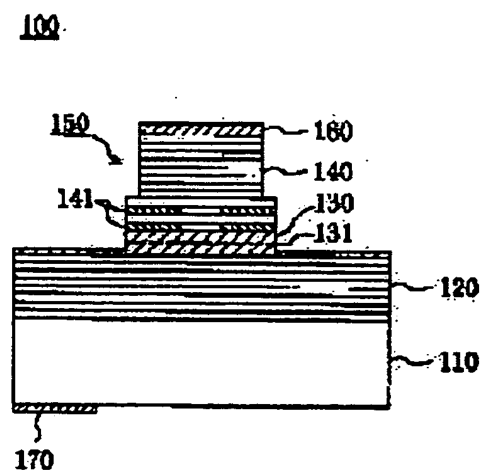
(54) SURFACE LIGHT EMITTING SEMICONDUCTOR LASER AND MANUFACTURING METHOD THEREOF

(57)Abstract:
PROBLEM TO BE SOLVED: To realize a surface light emitting semiconductor laser, which is capable of operating on a low threshold current and outputting a laser beam of high power using even a mirror of low resistance.
SOLUTION: An upper mirror 140 of a surface light emitting semiconductor laser 100 has such a structure that 24.5 pairs of P-type AlAs layers (first layer) and N-type GaAs layers (second layer) are laminated with N-type intermediate layers interposing between them to function as a distributed reflector (DBR). The upper mirror 140 is processed into a mesa 150. The mesa 150 is a two- storied mesa, the peripheries of the P-type AlAs layers included in the upper mesa are not oxidized, but the other P-type AlAs layers included in the lower mesa are selectively oxidized. Therefore, the P-type AlAs layers included in the lower mesa are divided into a peripheral selective oxide region 141 and a core-like semiconductor region surrounded with the oxide region 141. A



drive current is constricted by the insulating selective oxide region 141, so that it flows through the core-like semiconductor region in a longitudinal direction.

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CLAIMS

[Claim(s)]
[Claim 1] It is the field luminescence semiconductor laser possessing the active region containing a luminous layer, and two mirrors which face across said active region. At least one side of said two mirrors It has the distribution Bragg reflector (DBR) structure containing two or more 1st layer containing aluminum, and two or more 2nd layer. Field luminescence semiconductor laser which has the selective oxidation field where only the layer as which the part was chosen among said two or more 1st layer contained in said DBR structure contains aluminum, and the core semiconductor region surrounded by said selective oxidation field.
[Claim 2] It is the field luminescence semiconductor laser characterized by being field luminescence semiconductor laser according to claim 1, forming said core semiconductor region from the semi-conductor containing aluminum, and forming said 2nd layer from the semi-conductor which carries out lattice matching to the semi-conductor containing said aluminum.
[Claim 3] The layer which is field luminescence semiconductor laser according to claim 2, and has said selective oxidation field among said two or more 1st layer is field luminescence semiconductor laser characterized by being arranged in the location near [layer / which does not have said selective oxidation field among said two or more 1st layer in the DBR structure containing this layer] said active region.
[Claim 4] It is the field luminescence semiconductor laser characterized by being field luminescence semiconductor laser according to claim 3, and said DBR structure including the mesa at least in the part.
[Claim 5] It is the field luminescence semiconductor laser which contains two mesa parts from which said mesa of said DBR structure differs in an outer-diameter dimension as field luminescence semiconductor laser **** according to claim 4, and is characterized by forming said selective oxidation field in the mesa part of the side near said barrier layer among said two mesa parts.
[Claim 6] It is the field luminescence semiconductor laser which it is field luminescence semiconductor laser according to claim 4, and said mesa of said DBR structure contains the taper part at least in the part, and is characterized by said taper part having the inclined side attachment wall.
[Claim 7] It is the field luminescence semiconductor laser characterized by being field luminescence semiconductor laser according to claim 6, and covering said some of inclined side attachment walls [at least] of said mesa with the electrode.
[Claim 8] That by which it is field luminescence semiconductor laser according to claim 7, and the end face is covered with said electrode among said two or more 1st layer is field luminescence semiconductor laser characterized by not having said selective oxidation field substantially.
[Claim 9] Field luminescence semiconductor laser which is field luminescence semiconductor laser according to claim 1, and is characterized by the interlayer intervening between said 1st layer of said DBR structure, and said 2nd layer.
[Claim 10] Field luminescence semiconductor laser which is field luminescence semiconductor laser according to claim 1, and is characterized by the thing of said two mirrors for which it has said DBR structure and said any DBR structure has said selective oxidation field and said core semiconductor

region, respectively.
[Claim 11] It is the field luminescence semiconductor laser characterized by being field luminescence semiconductor laser according to claim 1, and forming one side of said two mirrors from the dielectric multilayer.
[Claim 12] It is the field luminescence semiconductor laser characterized by being field luminescence semiconductor laser according to claim 2, forming said core semiconductor region from AlAs, and forming said 2nd layer from GaAs.
[Claim 13] It is the field luminescence semiconductor laser possessing the active region containing a luminous layer, and two mirrors which face across said active region. At least one side of said two mirrors Only the layer as which the part was chosen among said two or more 1st layer which has the distribution Bragg reflector (DBR) structure containing two or more 1st layer containing aluminum and two or more 2nd layer, and is contained in said DBR structure A surface PASSHI bait field, Field luminescence semiconductor laser which has the core semiconductor region surrounded by said surface PASSHI bait field.
[Claim 14] It is the field luminescence semiconductor laser characterized by being field luminescence semiconductor laser according to claim 13, and forming said surface PASSHI bait field of the selective oxidation process.
[Claim 15] The 1st single mirror which is the field luminescence semiconductor laser by which two or more vertical resonators were arranged by one substrate, and is shared by said two or more vertical resonators, It has two or more active regions boiled and inserted into two or more 2nd mirrors which were alike, respectively and corresponded and said two or more 2nd mirrors of two or more of said vertical resonators, and said 1st mirror. Either [at least] said 1st mirror or the 2nd mirror It has the distribution Bragg reflector (DBR) structure containing two or more 1st layer containing aluminum, and two or more 2nd layer. Field luminescence semiconductor laser which has the selective oxidation field where only the layer as which the part was chosen among said two or more 1st layer contained in said DBR structure contains aluminum, and the core semiconductor region surrounded by said selective oxidation field.
[Claim 16] The process which forms the multilayer containing two or more 1st layer which is the manufacture approach of the field luminescence semiconductor laser equipped with the active region containing a luminous layer, and two mirrors which face across said active region, and contains aluminum, and two or more 2nd layer, The process at which said multilayer is selectively etched into by the 1st mesa etching, an up mesa part is formed in from said multilayer by it, and the side attachment wall of said up mesa part is exposed, The process at which said multilayer is etched into for said side attachment wall of said up mesa part still more deeply by the wrap process and the 2nd mesa etching by the protective coat, a lower mesa part is formed in by it, and the side attachment wall of said lower mesa part is exposed, The manufacture approach of the field luminescence semiconductor laser which includes said process which is included in said lower mesa part, and which oxidizes the 1st layer selectively from said side attachment wall of said lower mesa part.
[Claim 17] It is the manufacture approach of the field luminescence semiconductor laser which is the manufacture approach according to claim 16, and is characterized by performing said 1st mesa etching so that said side attachment wall of said up mesa part may be made to incline.
[Claim 18] It is the manufacture approach of the field luminescence semiconductor laser which is the manufacture approach according to claim 17, and is characterized by forming said protective coat from a conductive ingredient, and constituting some electrodes.
[Claim 19] The manufacture approach of the field luminescence semiconductor laser which is the manufacture approach according to claim 16, and is characterized by said oxidation process carrying out using H2O2.
[Claim 20] It is the manufacture approach of the field luminescence semiconductor laser which is the manufacture approach according to claim 16, and is characterized by performing said oxidation process using H2O2 which added ferric chloride.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the field luminescence semiconductor laser (Vertical-Cavity Surface-Emitting laser:VCSEL) and its manufacture approach of the vertical resonator mold manufactured especially using a selective oxidation process about field luminescence semiconductor laser and its manufacture approach.
[0002]
[Description of the Prior Art] It not only can obtain the light beam to which the cross section carried out the round shape, but according to the field luminescence semiconductor laser ("VCSEL" may be called simply hereafter) of a vertical resonator mold, it can integrate parts for two or more light-emitting part to high density on a single substrate two-dimensional. Moreover, a surface emission-type laser can operate with low power consumption, and can be manufactured by low cost. For such a description, VCSEL attracts attention as the light source for next-generation optical communication and optical information processing, and research and development various until now are performed.
[0003] Research which raises the engine performance of VCSEL is briskly done by oxidizing selectively the semi-conductor layer (for example, AlGaAs layer) which constitutes the mirror of the GaAs system VCSEL recently. An example of VCSEL using this selective oxidation process is indicated by the 562nd page (Electronics Letters, 31 (1995), P.560-562) from electronics Letters, the 31st volume (1995), and the 560th page.
[0004] Drawing 9 is the sectional view showing typically the structure of VCSEL currently indicated by the above-mentioned reference. VCSEL900 of drawing 9 is equipped with the vertical resonator arranged on the n mold GaAs substrate 910, and this resonator is equipped with n-DBR920, the InGaAs/GaAs deformation amount child well 930, and p-DBR (Distributed Bragg Reflector)940 in this sequence from the substrate side. Both the p mold DBR and the n mold DBR have the multilayer structure which the GaAs layer 941 and the AlAs/AlxOy layer 942 deposited by turns, and this multilayer structure is etched in the shape of a mesa until it results in a substrate 910. The AlAs/AlxOy layer 942 is formed from the AlAs field located in a mesa center section, and the AlxOy field which encloses it. An AlxOy field is obtained by oxidizing an AlAs layer selectively in a longitudinal direction from a mesa side attachment wall after a mesa etching process. The whole mesa is protected with polyimide 950. The output light 960 is taken out from the rear face of a substrate 910.
[0005] Next, actuation of VCSEL900 is explained.
[0006] Since an AlxOy field (part by which hatching is carried out with the slash in drawing 9) is an insulator, a current flows the AlAs field where a mesa center section (white part) is narrow. For this reason, a current locked-in effect is heightened. In the AlAs/AlxOy layer 942, since the refractive index of an AlAs field differs from the refractive index of an AlxOy field, refractive-index waveguide structure is formed and it realizes eye longitudinal direction ****** of light. Sharp reduction of a threshold current is expected by the locked-in effect of these currents and light.
[0007] The thin damage layer by mesa etching is formed in the mesa side attachment wall, and a

nonluminescent recombination center exists in this damage layer. For this reason, the current which flows near the mesa side attachment wall turns into the reactive current which does not contribute to luminescence. Since this structure where a current flows only in the mesa center section can make most reactive currents zero, the further reduction of a threshold current is expectable. VCSEL900 has realized the world's smallest value threshold current 70microA (microampere).
[0008] Other conventional examples are indicated by the 3415th page (Applied Physics Letter, 66 (1995), P.3413-3415) from an applied physics letter, the 66th volume (1995), and the 3413rd page. Drawing 10 is the sectional view showing typically the structure of VCSEL1000 currently indicated by the above-mentioned reference.
[0009] VCSEL1000 is equipped with the structure where the laminating of a barrier layer 1020 and p-DBR1030 was carried out, on n-DBR1010. The mesa is formed by etching this laminated structure to n-DBR1010. Moreover, the ring-like p lateral electrode 1040 is formed on p-DBR1030. p-DBR has the multilayer structure which carried out the laminating of AlGaAs and the GaAs by turns. Only the one-layer AlGaAs layer located in the lowest layer of multilayer structure is formed from the aluminum0.98Ga0.02As layer 1032 of aluminum presentation =0.98, and other layers are formed from the aluminum0.9Ga0.1As layer and GaAs layer of aluminum presentation =0.9. Consequently, DBR1033 of aluminum0.9Ga0.1 As/GaAs structure functions as an up mirror.
[0010] In this conventional example, using the oxidation rate difference (about 15:1) of aluminum0.98Ga0.02As and aluminum0.9Ga0.1As, only the aluminum0.98Ga0.02As layer 1032 is oxidized selectively, and the AlxOy field 1031 is formed.
[0011] The principle of operation of VCSEL1000 is fundamentally the same as the case of VCSEL900 of drawing 9 , and VCSEL of a low threshold current is realized.
[0012]
[Problem(s) to be Solved by the Invention] According to the 1st conventional technique, only the optical output of several microwatt order is obtained. Moreover, with the 2nd conventional technique, in order to oxidize only one layer, the hybrid mirror configuration using two kinds of AlGaAs layers from which aluminum presentation differs is adopted. aluminum presentation of the AlGaAs layer in which others do not oxidize is made small at one layer by which selective oxidation is carried out more to a detail using the AlGaAs layer (aluminum presentation is large) which is easy to oxidize. According to such a configuration, the AlGaAs layer (aluminum presentation is small) which shows the refractive index near the refractive index of a GaAs layer must be used for most mirrors. When the refractive-index difference between the GaAs layers and AlGaAs layers which constitute a mirror is small, in order to attain sufficient reflection factor, the number of layers of a mirror must be made [more] than the case where the AlGaAs layer of big aluminum presentation is used. It not only raises a manufacturing cost, but this causes the problem of making mirror resistance increase.
[0013] While this invention is made in view of these many points and the low mirror of resistance is used for the main object, actuation with a low threshold current is enabled, and it is in offering the field luminescence semiconductor laser which moreover attains a high optical output, and its manufacture approach.
[0014]
[Means for Solving the Problem] In order to attain the above-mentioned object, the selective oxidation field for a current constriction is selectively arranged by oxidizing only some layers chosen as two or more 2nd layer which constitutes the mirror from this invention, using the layer which contains aluminum in two or more 1st layer which constitutes a mirror among two or more 1st layer using the layer from which a refractive index and an oxidation rate differ in the 1st layer.
[0015] Specifically the 1st field luminescence semiconductor laser of this invention It is the field luminescence semiconductor laser possessing the active region containing a luminous layer, and two mirrors which face across said active region. At least one side of said two mirrors It has the distribution Bragg reflector (DBR) structure containing two or more 1st layer containing aluminum, and two or more 2nd layer. Only the layer as which the part was chosen among said two or more 1st layer contained in said DBR structure has the selective oxidation field containing aluminum, and the core semiconductor

region surrounded by said selective oxidation field.
[0016] A constriction can be efficiently carried out to the narrow space to which a current is specified in a core semiconductor region, controlling the increment in electric resistance of the whole DBR structure, since only some layers contained in DBR structure will include by this the selective oxidation field which prevents a current. Consequently, a current is poured into a narrow field among the luminous layers of active-region notes, and laser oscillation is attained with a low threshold current. DBR structure functions as a reflector from the difference in the refractive index of those layers including two or more 1st layer and two or more 2nd layer.
[0017] With a certain operation gestalt, said core semiconductor region is formed from the semi-conductor containing aluminum, and said 2nd layer can be considered as the configuration formed from the semi-conductor which carries out lattice matching to the semi-conductor containing said aluminum. By this, within limits which the current of DBR structure passes, it will be distorted and the semi-conductor will carry out the laminating that there is nothing.
[0018] As for the layer which has said selective oxidation field among said two or more 1st layer, it is more desirable than the layer which does not have said selective oxidation field among said two or more 1st layer in the DBR structure containing this layer to be arranged in the location near said active region. Since the structure for a current constriction will be arranged by this in the location near an active region, an efficient current constriction is attained. Moreover, it originates in the longitudinal direction refractive-index difference between a core semiconductor region and a selective oxidation field, and the light produced in the luminous layer is shut up within limits specified to a core semiconductor region.
[0019] Said DBR structure can be considered as the configuration which includes the mesa at least in the part. Thereby, current density is raised by the mesa and laser oscillation in a lower threshold is realized. Moreover, a selective oxidation field can be formed from the periphery section of a mesa, and a narrow core semiconductor region can be prepared easily.
[0020] Said mesa of said DBR structure contains two mesa parts from which an outer-diameter dimension differs, and said selective oxidation field can be considered as the configuration currently formed in the mesa part of the side near said barrier layer among said two mesa parts. Thereby, the efficiency of a current constriction can be raised, controlling the increment in electric resistance of a mesa.
[0021] Said mesa of said DBR structure contains the taper part at least in the part, and said taper part can be considered as the configuration which has the inclined side attachment wall. Thereby, it becomes easy to cover the taper part of DBR structure by the protective coat. Therefore, the thing which is included in the other part and which oxidize the 1st layer selectively becomes easy, without the 1st layer of the taper part of DBR structure oxidizing on the occasion of manufacture. Consequently, a manufacturing cost is reduced.
[0022] Said some of inclined side attachment walls [at least] of said mesa can be considered as the configuration covered with the electrode. Thereby, the contact resistance of an electrode and a mesa decreases and vertical resistance of a mirror part is reduced further.
[0023] That by which the end face is covered with said electrode among said two or more 1st layer can be considered as the configuration which does not have said selective oxidation field substantially. By this, an electrode may function as a protective coat in the case of a selective oxidation process into a production process.
[0024] Between said 1st layer of said DBR structure, and said 2nd layer, it can consider as the configuration between which the interlayer intervenes. distorted between the layers which constitute DBR structure by this -- it becomes possible for everybody to take care not to be generated, and the crystallinity improves.
[0025] Each of said two mirrors can consider as the configuration in which it has said DBR structure and said any DBR structure has said selective oxidation field and said core semiconductor region. By this, the selective oxidation field for a current constriction will be arranged to the both sides of two mirrors. Therefore, a current can be efficiently poured into the narrow range of a luminous layer.
[0026] One side of said two mirrors can be considered as the configuration currently formed from the

dielectric multilayer.

[0027] Said core semiconductor region is formed from AlAs, and said 2nd layer can be considered as the configuration currently formed from GaAs. Thereby, a selective oxidation field can be formed easily. It is because AlAs tends to oxidize remarkably as compared with GaAs. Moreover, the refractive-index difference between AlAs and GaAs is large, and can obtain a reflection factor with a high mirror with a small number of layers.

[0028] The active region where other field luminescence semiconductor laser by this invention contains a luminous layer, It is the field luminescence semiconductor laser possessing two mirrors which face across said active region. At least one side of said two mirrors Only the layer as which the part was chosen among said two or more 1st layer which has the distribution Bragg reflector (DBR) structure containing two or more 1st layer containing aluminum and two or more 2nd layer, and is contained in said DBR structure A surface PASSHI bait field, It has the core semiconductor region surrounded by said surface PASSHI bait field. Thereby, the reactive current can be reduced, without making mirror resistance completely increase. It is that they put on a surface PASSHI bait field, and replace although the side face of DBR structure includes many crystal defects of the nonluminescent recombination center which generates the reactive current by breakage received at the time of manufacture, and is because the cause of the reactive current decreases.

[0029] Said surface PASSHI bait field can be considered as the configuration currently formed of the selective oxidation process. By this, a PASSHI bait field can be formed easily. It is because the PASSHI bait of the 1st and the front face of the 2nd layer including a defect can be carried out simply according to the selective oxidation process.

[0030] The 1st single mirror which the field luminescence semiconductor laser of further others of this invention is field luminescence semiconductor laser by which two or more vertical resonators were arranged by one substrate, and is shared by said two or more vertical resonators, It has two or more active regions boiled and inserted into two or more 2nd mirrors which were alike, respectively and corresponded and said two or more 2nd mirrors of two or more of said vertical resonators, and said 1st mirror. Either [at least] said 1st mirror or the 2nd mirror It has the distribution Bragg reflector (DBR) structure containing two or more 1st layer containing aluminum, and two or more 2nd layer. Only the layer as which the part was chosen among said two or more 1st layer contained in said DBR structure has the selective oxidation field containing aluminum, and the core semiconductor region surrounded by said selective oxidation field. Thereby, the array of a surface emission-type laser is obtained. Since the configuration for a current constriction is prepared about each DBR structure which constitutes an array, a threshold current is reduced, consequently the whole power consumption becomes low.

[0031] The active region where the manufacture approach of the field luminescence semiconductor laser of this invention contains a luminous layer, The process which forms the multilayer containing two or more 1st layer which is the manufacture approach of the field luminescence semiconductor laser equipped with two mirrors which face across said active region, and contains aluminum, and two or more 2nd layer, The process at which said multilayer is selectively etched into by the 1st mesa etching, an up mesa part is formed in from said multilayer by it, and the side attachment wall of said up mesa part is exposed, The process at which said multilayer is etched into for said side attachment wall of said up mesa part still more deeply by the wrap process and the 2nd mesa etching by the protective coat, a lower mesa part is formed in by it, and the side attachment wall of said lower mesa part is exposed, From said side attachment wall of said lower mesa part, said process which is included in said lower mesa part and which oxidizes the 1st layer selectively is included. In order for this to cover only a part by the protective coat among the multilayers containing two or more 1st layer and two or more 2nd layer, only the 1st layer is oxidized exactly and the thing which are located in the part (lower mesa part) which is not covered by the protective coat and for which a selective oxidation field is formed easily becomes possible.

[0032] Said 1st mesa etching can be considered as the configuration performed so that said side attachment wall of said up mesa part may be made to incline. It becomes easy for this to deposit a protective coat on the side attachment wall of the inclined up mesa part.

[0033] Said protective coat is formed from a conductive ingredient, and you may make it said protective coat constitute some electrodes. The need of removing a protective coat is lost by this, and a production process is simplified.
[0034] Said oxidation process may be made to be performed using H2O2. Thereby, formation of a selective oxidation field is simplified and a manufacturing cost is also reduced.
[0035] Said oxidation process may be made to be performed using H2O2 which added ferric chloride. Thereby, an oxidation rate can be raised using an operation of ferric chloride.
[0036]
[Embodiment of the Invention] Below, the operation gestalt of this invention is explained, referring to an accompanying drawing.
[0037] (1st operation gestalt) Drawing 1 is the sectional view showing typically the field luminescence semiconductor laser (VCSEL) 100 by the 1st operation gestalt of this invention. VCSEL100 of drawing 1 is formed on the p mold GaAs substrate 110. VCSEL100 has the laminated structure for the laser oscillation containing p mold lower mirror 120, an active region 130, and n draw spike section mirror 140. The lower mirror 120 is formed on the substrate 110, and it faces across the active region 130 between the lower mirror 120 and the up mirror 140. Below, the configuration of the above-mentioned laminated structure is explained in detail.
[0038] Pinching 24.5 pairs of p mold AlAs layers (it corresponding to the 1st layer), and a p mold GaAs layer (it corresponding to the 2nd layer) for p mold interlayer in between, the lower mirror 120 has the structure which carried out the laminating, and functions as a lower distribution reflector (Distributed Bragg Reflector:DBR). Similarly, pinching 24.5 pairs of n mold AlAs layers (it corresponding to the 1st layer), and an n mold GaAs layer (it corresponding to the 2nd layer) for n mold interlayer in between, the up mirror 140 has the structure which carried out the laminating, and functions as an upper distribution reflector (DBR).
[0039] It has not the hybrid configuration whose conventional technique of drawing 10 has adopted any mirror but the single configuration. In addition, on this application descriptions, the **** a "single configuration" is used in the sense of different structure from a "hybrid configuration" which is used for the conventional technique of drawing 10 .
[0040] The active region 130 has the barrier layer (luminous layer) 131 with the deformation amount child well containing the GaAs layer which functions as the In0.2Ga0.8As layer which functions as a well layer, and a barrier layer, and the aluminum0.5Ga0.5As cladding layer which puts this barrier layer 131. The active region 130 is designed so that the light whose wavelength is about 980nm may be oscillated.
[0041] VCSEL100 has the mesa 150. This mesa 150 contains two steps of mesa parts, and the way of the mesa part below a upside mesa part has the big outer-diameter dimension. The outer diameter of an up mesa part [in / in a detail / this operation gestalt] is about 10 micrometers more, and the outer diameter of a lower mesa part is about 11 micrometers. The mesa 150 with such two-step structure is formed of the mesa etching process of two steps so that it may mention later. The up mesa part contains most up mirrors 140. On the other hand, the lower mesa part contains a part of up mirror 140 (pars basilaris ossis occipitalis), the up cladding layer, the barrier layer 131, and a part of lower cladding layer. Since the 2nd mesa etching stops before exposing the top face of the lower mirror 120 thoroughly, the top face of the lower mirror 120 is covered with the lower cladding layer so that drawing 1 may show.
[0042] Although the periphery of the p mold AlAs layer contained in an up mesa part has not oxidized, the periphery of the p mold AlAs layer contained in a lower mesa part has oxidized selectively. Consequently, the p mold each AlAs layer contained in a lower mesa part is divided into the surrounding selective oxidation field 141 and the semiconductor region of the shape of a core surrounded by the selective oxidation field 141. The selective oxidation field 141 functions as current aperture. The actuation current for laser oscillation flows the inside of a core semiconductor region to a lengthwise direction, as a result of a constriction's being carried out by the insulating selective oxidation field 141. The size (diameter) of a core semiconductor region is reduced according to progress of

longitudinal direction oxidation. It mentions later for details about this point.
[0043] According to this operation gestalt, etching for forming a mesa 150 stops, when etching selectively a barrier layer 131 and the lower part cladding layer located between the lower mirrors 120. Consequently, although the up cladding layer and the barrier layer 131 are contained in the lower mesa part, the lower mirror 120 does not receive mesa etching at all, and they do not have the shape of mesa. For this reason, the AlAs layer in the lower mirror 120 does not oxidize according to a selective oxidation process, but the selective oxidation field 141 for carrying out the constriction of the light to a current is formed only in the barrier layer 131 upside.
[0044] VCSEL110 has further the n lateral electrode 160 formed in the top face of the up mirror 140, and the p lateral electrode 170 formed in the rear face of p mold substrate 110, and a current is supplied to an active region 130 with these electrodes 160 and 170. The laser beam produced within the vertical resonator is taken out from the rear face of a substrate 110.
[0045] Next, the manufacture process of VCSEL100 is explained, referring to drawing 2 (a) - (d). In addition, in drawing 2 (a) - (d), the same reference mark as the same component as what was shown by drawing 1 is attached, and the explanation is omitted.
[0046] first, it is shown in drawing 2 (a) -- as -- the semi-conductor substrate 110 top -- two or more semi-conductor layers for the lower mirror 120, an active region 130, and the up mirror 140 -- MBE -- law (molecular beam epitaxy method) and MOCVD -- it grows epitaxially by law (metal-organic chemical vapor deposition) etc. In this way, the n lateral electrode 160 and the p lateral electrode 170 are formed in the obtained VCSEL wafer. Patterning of the n lateral electrode 160 is carried out using the photo mask for specifying the location and configuration of an up mesa part. The n lateral electrode 160 is formed from Au/AuGe/nickel (5nm in thickness of thickness 150 nm:nickel of thickness 100 nm:AuGe of Au), and the p lateral electrode 170 is formed from Cr/Au (150nm in thickness of thickness 50 nm:Au of Cr).
[0047] Next, the 1st mesa etching is performed using the RIE method using Cl2. The etching conditions are as follows. Cl2: Ar:CF 4= 1:10:3, power:500W, etching time:50 minutes.
[0048] The n lateral electrode 160 functions as a mask to this etching. This etching is controlled to stop on the level in the middle of the up mirror 140 to be shown in drawing 2 (a). Consequently, it leaves the 1st mesa etching without etching the two-layer n mold AlAs layer most located near the barrier layer 131 among the up mirrors 140.
[0049] Next, the top face and side attachment wall of an up mesa part which were formed by the 1st mesa etching are covered by SiO2 protective coat, as shown in drawing 2 (b). This SiO2 protective coat is obtained by removing selectively the part in contact with the field (field parallel to a substrate front face) of ** in an up mirror exposed by the 1st mesa etching among SiO2 film, after depositing SiO2 film with a thickness of 500nm for example, using a plasma-CVD method so that the whole surface of a substrate may be covered. In order to perform such alternative clearance, the photo mask for specifying the location and configuration of SiO2 protective coat is needed. This photo mask differs from the photo mask used for patterning of the n lateral electrode 160 in pattern size. In addition, when depositing SiO2 protective coat with physical vapor deposition, such as the sputtering method, a taper is formed in an up mesa part and it is needed to make the side attachment wall of an up mesa part incline. A SiN protective coat may be used instead of SiO2 protective coat.
[0050] next, RIBE using Cl2 -- the 2nd mesa etching is performed using law. The etching conditions are as follows. Cl2: H2=1:1, power:200W, acceleration voltage: 500 volts, etching time:50 minutes. SiO2 protective coat functions as a mask to this etching. This etching is controlled to go on to directly under [of an active region 130].
[0051] Then, as shown in drawing 2 (c), an oxidation kind is supplied to the interior of a lower mesa part in a longitudinal direction from the side attachment wall of a lower mesa part exposed by the 2nd mesa etching. In this way, only the periphery of the AlAs layer contained in a lower mesa part is oxidized selectively, and the selective oxidation field 141 is formed. AlAs containing aluminum has a remarkably large oxidation rate as compared with GaAs which does not contain aluminum, consequently selective oxidation is produced to AlAs. Since an oxidation kind cannot diffuse SiO2 protective coat

promptly, the up mesa part in which the side face is covered with SiO2 protective coat does not oxidize. Thus, SiO2 protective coat functions also as the antioxidizing film or an oxidation mask.
[0052] Finally, as shown in drawing 2 (d), SiO2 protective coat is removed by the RIE method using CF4, and the structure shown in drawing 1 is acquired.
[0053] As mentioned above, it functions as SiO2 protective coat of drawing 2 (c) preventing the selective oxidation of the AlAs layer contained in an up mesa part in the above-mentioned selective oxidation process. If this SiO2 protective coat is fully thick, since SiO2 protective coat will function as powerful antioxidizing film, a selective oxidation field is not formed in an up mesa part. However, if the thickness of SiO2 protective coat is thin in comparison, a selective oxidation field may be slightly formed also in an up mesa part. If the effect of the current constriction produced by it is small even if it resembles an up mesa part comparatively even if and a small selective oxidation field is formed, the increment in mirror resistance will be eased fairly. Therefore, even when SiO2 protective coat does not prevent the selective oxidation of an up mesa part thoroughly, as for a certain extent, improvement in an optical output can be expected. In the case of this operation gestalt, the range of thickness with SiO2 desirable protective coat is about 300nm to about 500nm.
[0054] Drawing 3 is the outline block diagram of the oxidation system used for the above-mentioned selective oxidation. As shown in drawing 3 , bubbling of N2 is carried out by H20 [about 80-degree C], and N2 which contained H20 by it is introduced into the furnace heated at about 380 degrees C. Other inert gas, such as Ar, may be used instead of N2. VCSEL is put in into this furnace and a part of front face of VCSEL is oxidized. The size (size of the longitudinal direction measured in the direction of a mesa core from the mesa side-attachment-wall front face) of a selective oxidation field is adjusted by controlling oxidation time amount.
[0055] Drawing 4 is a graph which shows the relation between oxidation time amount and the optical output-current characteristic of VCSEL. The mesa used for measurement has the shape of a cylindrical shape, and the diameter is 10 microns. The curve of drawing 4 R> 4 shows the property in case oxidation time amount is 0 second (it does not oxidize), 2 minutes and 30 seconds, and 4 minutes and 30 seconds. When oxidation time amount is 0 second, a threshold current is about 4mA. When oxidation time amount is 2 minutes and 30 seconds to it, in the case of about 3.2mA, and 4 minutes and 30 seconds, a threshold current is about 1.7mA. A threshold current decreases, so that the graph of drawing 4 may show and oxidation time amount increases. It is because a selective oxidation field becomes large in a longitudinal direction, consequently extent of a current constriction becomes strong as oxidation time amount of this increases. When oxidation time amount is 4 minutes and 30 seconds, the selective oxidation field whose lateral size (width of face) is about 1-2 micrometers is formed, and the diameter of a core semiconductor region is decreasing from about 11 micrometers to about 7-9 micrometers. Thus, a current and light close existence of the selective oxidation field 141 in the circumference of a mesa, and it attains eye **, reduces the reactive current, consequently reduces a threshold current. With this operation gestalt, since only the two-layer AlAs layer has oxidized among up mirror parts, resistance of a mirror hardly increases. Therefore, without producing most problems by generation of heat at the time of device actuation, the maximum optical output is not restricted by generation of heat so that drawing 4 may see.
[0056] On the other hand, when oxidation time amount is 2 minutes and 30 seconds, most selective oxidation fields are not formed. In this case, the longitudinal direction size of the selective oxidation field formed is considered to be 0.1 micrometers or less. Therefore, the locked-in effect of the current by existence of a selective oxidation field and light is hardly expectable. Nevertheless, the PASSHI bait of the damage layer of a mesa surface is carried out by the selective oxidation process, and it is considered to be because for the reactive current to have decreased by it that the threshold current is fully decreasing.
[0057] As mentioned above, the laser mesa 150 is formed by two steps of etching VCSEL100 of this operation gestalt. And by protecting an up mesa part by SiO2 protective coat, only the AlAs layer of the up mirror 140 contained in a lower mesa part is oxidized selectively, and the two-layer selective oxidation field 141 is formed by it. Consequently, a threshold current can be reduced, without increasing

resistance of the up mirror 140, even if it uses a selective oxidation process.
[0058] As for the number of layers of the selective oxidation field 141, from a viewpoint of keeping mirror resistance small, it is most desirable that it is 1. The selective oxidation field 141 of effectiveness is [at least one layer] enough in the slight closing depth of the longitudinal direction of a current. However, as for the viewpoint of making effectiveness high in the slight closing depth of the longitudinal direction of light to the selective oxidation field 141, it is desirable to be arranged as mostly within limits by which light spreads and comes out from a barrier layer 131 in the vertical direction as possible. If these things are taken into consideration, it will be thought that the number of layers of the selective oxidation field 141 is in the range from 1 to 5 preferably, and is in the range to 1-3 more preferably.
[0059] In addition, apart from the operation gestalt of drawing 1 , the operation gestalt to which it oxidizes thinly and a selective oxidation field does not contribute substantially only the maximum surface (for example, field with a depth [a front face to] of 0.1 micrometers or less) of the side attachment wall of a mesa 150 to the longitudinal direction constriction of a current may be adopted. As mentioned above, it is from the ability of the PASSHI bait of the damage layer which only exposes a mesa front face to an oxidizing atmosphere, and was formed in the side-attachment-wall front face of a mesa 150 to be carried out (formation of a PASSHI bait field). A threshold current can be reduced without making mirror resistance completely increase, since the reactive current by the nonluminescent recombination center can be reduced by this.
[0060] (2nd operation gestalt) Drawing 5 is the sectional view showing typically the configuration of VCSEL500 by the 2nd operation gestalt of this invention. In addition, the same reference number is given to the same component as VCSEL100 of the 1st operation gestalt, and the explanation is omitted here.
[0061] The upper part of the laser mesa 520 has the taper configuration (from the summit of the up mirror 140 to the middle of an active region 130). The n lateral electrode 160 is formed so that the top face of this taper part and the sloping side face may be covered. Moreover, the laser mesa 520 is formed by etching the lower mirror 120 by Fukashi who etches only one pair. The selective oxidation field 510 of one layer has extended in the longitudinal direction toward the interior of a mesa from the part which is not covered with the n lateral electrode 160 among the side attachment walls of a mesa 520.
[0062] With this operation gestalt, as shown in drawing 5 , only the best AlAs layer of p mold lower mirror 120 was oxidized selectively, and it has realized a lateral current constriction. On the other hand, with the 1st operation gestalt, as shown in drawing 1 , the AlAs layer of n draw spike section mirror is oxidized, and a current constriction is performed. The difference in the property of VCSEL by the difference among these current constrictions is explained using drawing 6 (a) and drawing 6 (b). Drawing 6 (a) is a typical sectional view at the time of performing a current constriction by n mold mirror side, and, in the case of the 1st operation gestalt, corresponds. Since there is a certain amount of distance (abbreviation one half of the thickness of an active region 130) in accuracy between the selective oxidation field 141 which performs a current constriction, and the barrier layer 131 which is a luminous layer as shown in drawing 6 (a), a current path will spread to some extent in the meantime. Therefore, a actual luminescence field becomes larger than the field by which a constriction was carried out in the selective oxidation field 141. The phenomenon of this luminescence field amplification happens by the same principle, also when a current constriction is performed by p mold mirror side of drawing 6 (b) (this operation gestalt). However, extent of amplification of a luminescence field differs by whether the active region 130 where amplification of a current path takes place is n mold, or it is p mold. That is, since current breadth is small, as the direction of p mold field where the current by the hole where mobility is small is dominant shows drawing 6 (a) and drawing 6 (b), a luminescence field becomes small from the case where the direction of this operation gestalt is the 1st operation gestalt. Thus, in VCSEL500 of this operation gestalt, rather than VCSEL100 of the 1st operation gestalt, the locked-in effect of a bigger current and light can be obtained, and a threshold current can be reduced further.
[0063] Next, the manufacture process of VCSEL500 is explained, referring to drawing 7 (a) - (d). In

addition, the same reference mark is given to the same component as what was shown by drawing 5 R> 5, and the explanation is omitted here.
[0064] first, it is shown in drawing 7 (a) -- as -- the semi-conductor substrate 110 top -- two or more semi-conductor layers for the lower mirror 120, an active region 130, and the up mirror 140 -- MBE -- law (molecular beam epitaxy method) and MOCVD -- it grows epitaxially by law (metal-organic chemical vapor deposition) etc. In this way, the lower layer of the n lateral electrode 160 and the p lateral electrode 170 are formed in the obtained VCSEL wafer. Patterning of the lower layer of the n lateral electrode 160 is carried out so that the location and configuration of an up mesa part may be specified. The lower layer of the n lateral electrode 160 is formed so that an electrode edge may become taper-like using the lift-off method etc. The lower layer of the n lateral electrode 160 is formed from Au/AuGe/nickel (5nm in thickness of thickness 150 nm:nickel of thickness 100 nm:AuGe of Au), and the p lateral electrode 170 is formed from Cr/Au (150nm in thickness of thickness 50 nm:Au of Cr).
[0065] Next, as shown in drawing 7 (b), the 1st mesa etching is performed using the RIE method using Cl_2. The n lateral electrode 160 functions as a mask to this etching. It is made for this etching to arrive at the interior of the barrier layer field 130 across the lowest edge of the up mirror 140 with this operation gestalt.
[0066] Next, after forming the up layer (additional layer) of the n lateral electrode 160 so that the side attachment wall of an up mesa may be covered as shown in drawing 7 (c), the 2nd mesa etching is performed using the RIE method using Cl_2. The up layer of the n lateral electrode 160 is formed from nickel (400nm in thickness). The n lateral electrode 160 functions as a mask to the 2nd etching. This etching is controlled to etch even the AlAs layer nearest to the top face of the lower mirror 120.
[0067] Finally, as shown in drawing 7 (d), only the best AlAs layer of the lower mirror 120 is oxidized from the exposed mesa side-attachment-wall front face, and the selective oxidation field 510 is formed.
[0068] Next, the oxidation approach used with this operation gestalt is explained.
[0069] This oxidization is performed by carrying out boiling of 500 in VCSELH_2O_2. Selective oxidation can be easily realized by the simple approach, without using the large-scale equipment which this used in the process which manufactures VCSEL100 of the 1st operation gestalt as shown in drawing 3 .
[0070] Furthermore, in the manufacture process of VCSEL500 of this operation gestalt, the lower layer of the n lateral electrode 160 is used as an etching mask of an up mesa part (refer to drawing 7 (a)). Since the lower layer of the n lateral electrode 160 has a taper configuration in an edge, a mask edge is etched little by little during etching, and it retreats in a longitudinal direction. In other words, while the longitudinal direction size of an etching mask (lower layer of the n lateral electrode 160) contracts, mesa etching advances. Consequently, as shown in drawing 7 (b), the configuration of an up mesa part also turns into the shape of a taper to which the side attachment wall became slanting. A cone angle turns into about 80 degrees. A photo mask is required, in order to carry out patterning of the up layer of the n lateral electrode 160 so that the up layer of the n lateral electrode 160 may cover only the top face and side face of an up mesa part. Since the same thing as the photo mask used for forming the lower layer of the n lateral electrode 160 should just be used for this photo mask, it does not need to create a photo mask in an excess.
[0071] As mentioned above, in VCSEL500 of this operation gestalt, selective oxidation is performed to p mold lower mirror 120, and a current constriction is performed within p mold lower mirror 120. Consequently, rather than the case where selective oxidation is performed to n draw spike section mirror 140, a stronger current and light can close, eye ** can be realized, and a threshold current can be reduced further.
[0072] Moreover, since it is etched so that an up mesa part may have a taper configuration, as compared with the case of the first operation gestalt, one number of sheets of a photo mask can be reduced. Consequently, VCSEL can be manufactured more by low cost.
[0073] Moreover, as a result of performing selective oxidation by carrying out boiling in $2OH_2$, VCSEL which had selective oxidation easily is realizable by the simple approach.
[0074] (3rd operation gestalt) Drawing 8 is the sectional view showing typically the configuration of

VCSEL800 by the 3rd operation gestalt of this invention. In addition, the same reference number is given to the same component as VCSEL100 of the 1st operation gestalt, and the explanation is omitted here.
[0075] The laser mesa 820 contains the up mesa part (diameter of about 10 micrometers), and the lower mesa part (diameter of about 11 micrometers). An up mesa part is formed by performing the 1st mesa etching by Fukashi who leaves the one lowest pair of the up mirror 140, and the lower mesa part is formed from the 2nd mesa etching which etches one pair of lower mirror 120.
[0076] The lower mesa part of the laser mesa 820 has a diameter larger than an up mesa part about 1 micrometer. The two-layer AlAs layer contained in the lower mesa part has oxidized selectively toward the mesa center section from the mesa side attachment wall, and the two-layer selective oxidation field 810 is formed.
[0077] With this operation gestalt, as shown in drawing 8 , the AlAs layer of both n draw spike section mirror 140 and p mold lower mirror 120 is oxidized selectively. Consequently, a current constriction is performed by the upper and lower sides of an active region 130, and the breadth of a current path does not arise. Therefore, a perfect current and light can close, eye ** can be realized, and a low threshold current is attained rather than VCSEL500 of the 2nd operation gestalt.
[0078] Next, the manufacture production process of VCSEL800 is explained.
[0079] The fundamental part of a process is the same as the thing of the manufacture process of VCSEL100 of the 1st operation gestalt. A point of difference is in the difference in the etching depth of two mesa etching, and the difference in the oxidation approach. The etching depth is controlled on the occasion of the 1st mesa etching to leave the one lowest pair of the up mirror 140, and is controlled on the occasion of the 2nd mesa etching to etch only the one best pair of the lower mirror 120. Each control of these etching depth is performed by adjusting etching time. In addition, with this operation gestalt, although the selective oxidation field 810 of one layer was formed in the both sides of a barrier layer, respectively, the number of the selective oxidation fields 810 is not limited to this. For example, the selective oxidation field 810 of one layer may be established in an active-region 130 upside, and the two-layer selective oxidation field 810 may be established in the active-region 130 bottom.
[0080] Selective oxidation for forming an active region 810 is performed using the mixed liquor of H2O2 and FeCl2 (iron(II) chloride). Mixed liquor is created by mixing 100 cc H2O2 and 0.025g FeCl2, and is heated at about 60 degrees C. Selective oxidation is performed by dipping VCSEL into this heated mixed liquor. The depth to the direction of a mesa core of oxidation is controlled by adjusting oxidation time amount. Since FeCl2 which promotes oxidation is used for this approach, it can perform oxidation more effective than the oxidation approach used for VCSEL500 of the 2nd operation gestalt in a short time. In addition, you may oxidize by using FeCl3 (iron(III) chloride) instead of FeCl2. This oxidation approach may be applied to the selective oxidation of VCSEL of drawing 1 R> 1 and drawing 5 , and the oxidation approach in the 1st or 2nd operation gestalt may be applied to reverse at the selective oxidation of VCSEL of drawing 8 . The structure of VCSEL does not limit especially the oxidation approach for manufacturing it.
[0081] In VCSEL800 of this operation gestalt, as explained above, as a result of oxidizing selectively the AlAs layer of both n draw spike section mirror 140 and p mold lower mirror 120 and performing a current constriction by the upper and lower sides of an active region 130, a perfect current and light can close, eye ** can be performed, and VCSEL of a low threshold current can be realized. Moreover, since three are oxidized in addition to FeCl2 or FeClH2O2 with the work which promotes the oxidation by H2O2, a selective oxidation process more effective in a short time can be performed.
[0082] (4th operation gestalt) Drawing 11 is the sectional view showing typically VCSEL1100 by the 4th operation gestalt of this invention. VCSEL1100 of drawing 11 is formed on the p mold GaAs substrate 110. VCSEL1100 has the laminated structure for the laser oscillation containing the lower dielectric mirror 1120, an active region 130, and n draw spike section mirror 140. The lower dielectric mirror 1120 is formed in opening prepared by selective etching from the rear face of a substrate 110. The active region 130 is formed on the substrate 110, and it faces across it between the lower dielectric mirror 1120 and the up mirror 140. The configuration of the above-mentioned laminated structure has

the same configuration as the 1st operation gestalt except for the lower dielectric mirror 1120. The lower dielectric mirror 1120 has the structure where the laminating of five pairs of SiO two-layer / TiO two-layer was carried out.
[0083] The mesa 150 contains two steps of mesa parts, and the way of the mesa part below a upside mesa part has the big outer-diameter dimension. The outer diameter of an up mesa part [in / in a detail / this operation gestalt] is about 8 micrometers more, and the outer diameter of a lower mesa is about 9 micrometers. The mesa 150 with such two-step structure is formed by the manufacture approach which described the 1st operation gestalt.
[0084] Although the periphery of the p mold AlAs layer contained in an up mesa part has not oxidized, the periphery of the p mold AlAs layer contained in a lower mesa part has oxidized selectively. Consequently, the p mold each AlAs layer contained in a lower mesa part is divided into the surrounding selective oxidation field and the semiconductor region of the shape of a core surrounded by the selective oxidation field. A selective oxidation field functions as current aperture. The actuation current for laser oscillation flows the inside of a core semiconductor region to a lengthwise direction, as a result of a constriction's being carried out by the insulating selective oxidation field.
[0085] With this operation gestalt, the 1st layer in which only one side of the mirrors of a couple contains aluminum, and the 1st layer were equipped with the DBR structure where the laminating of the 2nd layer from which a refractive index differs was carried out, and has oxidized selectively [two-layer / near an active region 130] only the 1st layer (layer containing aluminum which is easy to oxidize). Thus, one side of a vertical mirror may be constituted from a different ingredient layer from another side by this invention.
[0086] (5th operation gestalt) Drawing 12 is the sectional view showing typically the VCSEL array 1200 by the 5th operation gestalt of this invention. The VCSEL array 1200 of drawing 12 is equipped with the structure where two or more light-emitting parts (vertical resonator) were accumulated on one substrate. The same reference number is given to the same component as VCSEL100 of the 1st operation gestalt, and the explanation is omitted here.
[0087] The lower mirror 120 is shared between this operation gestalt by two or more vertical resonators, and an actuation current flows between the lower mirror 120 and each up mirror 140 with it. Consequently, laser oscillation arises within each resonator. Since structure and the same structure are established in the slight current and the optical closing depth of the 1st operation gestalt in each resonator, a low threshold current is attained and, moreover, a high optical output is obtained.
[0088] In addition, in the operation gestalt of all above, even if it replaces p mold and n mold, the effectiveness of the invention in this application is not spoiled. Moreover, it cannot be overemphasized that ingredient systems, such as InP systems other than a GaAs system and a GaN system, may be used.
[0089] As mentioned above, according to this invention, though it is the mirror of a single configuration by having an above-mentioned configuration, even if it uses a selective oxidation process, resistance of a mirror does not increase, but the field luminescence semiconductor laser of low resistance and a low threshold current is offered.
[0090]
[Effect of the Invention] A constriction can be efficiently carried out to the narrow space to which a current is specified in a core semiconductor region, controlling the increment in electric resistance of the whole DBR structure, since only some layers contained in DBR structure will include the selective oxidation field which prevents a current according to invention according to claim 1 as explained above. Consequently, a current is poured into a narrow field among the luminous layers of active-region notes, and laser oscillation is attained with a low threshold current.
[0091] According to invention according to claim 2, by within the limits which the current of DBR structure passes, it will be distorted and the semi-conductor will carry out the laminating that there is nothing.
[0092] According to invention according to claim 3, since the structure for a current constriction will be arranged in the location near an active region, an efficient current constriction is attained. Moreover, it originates in the longitudinal direction refractive-index difference between a core semiconductor region

and a selective oxidation field, and the light produced in the luminous layer is shut up within limits specified to a core semiconductor region.
[0093] According to invention according to claim 4, current density is raised by the mesa and laser oscillation in a lower threshold is realized. Moreover, a selective oxidation field can be formed from the periphery section of a mesa, and a narrow core semiconductor region can be prepared easily.
[0094] According to invention according to claim 5, the efficiency of a current constriction can be raised, controlling the increment in electric resistance of a mesa.
[0095] According to invention according to claim 6, it becomes easy to cover the taper part of DBR structure by the protective coat. Therefore, the thing which is included in the other part and which oxidize the 1st layer selectively becomes easy, without the 1st layer of the taper part of DBR structure oxidizing on the occasion of manufacture. Consequently, a manufacturing cost is reduced. Moreover, the pattern of a protective coat can also be specified using the photo mask used in order to specify the pattern of the etching mask for mesa formation.
[0096] According to invention according to claim 7, when an electrode covers the side attachment wall of a taper part, mirror resistance is reduced further.
[0097] According to invention according to claim 8, an electrode may function as a protective coat in the case of a selective oxidation process into a production process.
[0098] distorted between the layers which constitute DBR structure according to invention according to claim 9 -- it becomes possible for everybody to take care not to be generated, and the crystallinity improves.
[0099] According to invention according to claim 10, the selective oxidation field for a current constriction will be arranged to the both sides of two mirrors. Therefore, a current can be efficiently poured into the narrow range of a luminous layer.
[0100] According to invention according to claim 11, a manufacturing cost can be reduced.
[0101] According to invention according to claim 12, a selective oxidation field can be formed easily. It is because AlAs tends to oxidize remarkably as compared with GaAs. Moreover, the refractive-index difference between AlAs and GaAs is large, and can obtain a reflection factor with a high mirror with a small number of layers.
[0102] According to invention according to claim 13, the reactive current can be reduced, without making mirror resistance completely increase. It is that they put on a surface PASSHI bait field, and replace although the side face of DBR structure includes many crystal defects of the nonluminescent recombination center which generates the reactive current by breakage received at the time of manufacture, and is because the cause of the reactive current decreases.
[0103] According to invention according to claim 14, a PASSHI bait field can be formed easily. It is because the PASSHI bait of the front face including a defect of the 1st layer and the 2nd layer can be carried out simply according to the selective oxidation process.
[0104] According to invention according to claim 15, the array of a surface emission-type laser is obtained. Since the configuration for a current constriction is prepared about each DBR structure which constitutes an array, a threshold current is reduced, consequently the whole power consumption becomes low.
[0105] Since only a part will be covered by the protective coat among the multilayers containing two or more 1st layer and two or more 2nd layer according to invention according to claim 16, only the 1st layer is oxidized exactly and the thing which are located in the part (lower mesa part) which is not covered by the protective coat and for which a selective oxidation field is formed easily becomes possible.
[0106] According to invention according to claim 17, it becomes easy to deposit a protective coat on the side attachment wall of the inclined up mesa part.
[0107] According to invention according to claim 18, the need of removing a protective coat is lost and a production process is simplified.
[0108] According to invention according to claim 19, formation of a selective oxidation field is simplified and a manufacturing cost is also reduced.

[0109] According to invention according to claim 20, an oxidation rate can be raised using an operation of ferric chloride.

[Translation done.]